

The Visual Ecology of Prescribed Fire in Sequoia National Park¹

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Abstract: Preservation and restoration of natural ecosystems is important to maintain the dynamic character which ultimately formed the giant sequoia/mixed-conifer forests prior to human interference. In the Giant Forest, aesthetic and ecological goals need not conflict, but should complement each other as much as possible. This can be achieved by utilizing the recommendations from recent aesthetic research on prescribed fire management sponsored by Sequoia National Park. Management should seek to mitigate the effects of past fire suppression and mimic natural fire patterns while educating park visitors about fire ecology. Management must also recognize that areas of intense cultural use have impacts that are not natural, and these areas must be managed intensely to preserve and restore naturalness.

The National Park Service Act of 1916 (USA 1916) declared that "the fundamental purpose of [a National Park] is to conserve the scenery and, the natural and historic objects and the wildlife therein and to provide for enjoyment of the same in such a manner and by such a means as will leave them unimpaired for the enjoyment of future generations." Interpretation of this mandate with a sophisticated level of management was clearly demanded by the release of the Leopold Panel Report (Leopold and others 1963). The relationship between aesthetics and natural process is a complex natural and cultural issue that continues to evolve and will do so through ongoing multidisciplinary research. Visual resources are a prime asset in our National Parks and they must be conserved and managed sensitively.

Prescription burning began in the Giant Forest of Sequoia National Park in 1979. Since then several burns have been conducted. The management objectives of these burns have been primarily to reduce hazardous fuel accumulations and to restore the forest to a more natural ecosystem while sustaining populations of giant sequoias (*Sequoia-dendron giganteum*) (National Park Service 1987a). The overall burn pattern on the forested landscape was originally designed to prevent or minimize the potential risk of a catastrophic fire sweeping over the Giant Forest plateau. In an effort to accomplish these objectives, park resource managers were presented with a variety of sometimes conflicting goals. In 1986, an independent review was commissioned by Mr. Chapman, then Director of the USDI National Parks Service Western Region.

The independent review of the giant sequoia/mixed-conifer prescribed burning program of Sequoia and Kings

Canyon National Parks by the Christensen Panel resulted in a report (Christensen and others 1987). Which among many recommendations, explicitly addressed aesthetic concerns within the park's "Showcase" areas. The Sequoia Natural Resources Management Division has since changed the term "Showcase" to Special Management Areas (SMA). The Sequoia and Kings Canyon Vegetation Management Plan (NPS 1987b) notes that SMAs are designated "where maintenance of natural processes is guided more by scenic concerns." The Panel Report specifically recommended consultation with landscape architects in the development of burn plans with special emphasis on the SMAs. The three primary sources of visual impact of concern to landscape architects and many others are the reintroduction of fire, visitor overuse, and overgrown thickets of non-fire climax species.

Special Management Areas are located in the most heavily visited portions of the park. High visitation via roads and trails are a significant anthropogenic impact within an ecosystem that has management goals for 'naturalness.' The challenge of maintaining a natural aesthetic for this type of visitation is made compelling by the fact that roads and trails concentrate human impacts and have human facilities associated with them (food vendors, parking lots, restrooms, etc.). Current management goals of 'naturalness' are further complicated by historic-cultural values that have developed over the past one hundred years since the establishment of the park. The named trees and logs have become 'cultural objects' along trails and roads, such as the General Sherman Tree and other named trees, groves, logs, and stumps in the Giant Forest. These areas of heavy visitation and subsequent substantial human impact must be managed more intensively than elsewhere in the park and thus are termed SMAs.

As stated in the Panel Report, SMAs should not be seen as "static museums," created through "scene" management, but rather as a part of dynamic ecosystems, sensitively managed to preserve scenic and ecological resources (Christensen and others 1987). The Prescribed Fire Management Program (1987a) notes that the intention of management in these areas is not to apply a method of "greenscreening," whereby dramatically different appearing landscapes exist behind SMAs. Instead, these areas should be burned as more sensitive units with special attention given to specific goals and objectives for visual quality and interpretation, as complemented by associated resource objectives.

Historically, the giant sequoia/mixed-conifer ecosystem experienced frequent, low intensity fires which structured the forest prior to human interference (Kilgore 1987). The effects of past management actions in suppressing all natural

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lightning fires, for some seventy-five years (representing many natural fire cycles), has resulted in an altered forest structure and high ground fuel accumulation in many areas. The forest structure has been changed to favor shade tolerant fir and incense cedar while unnaturally high fuel accumulation risks increased mortality of giant sequoias and understory species during a fire (Harvey 1985; Kilgore 1985; Bonnicksen and Stone 1982; Bonnicksen 1975). Past prescribed fires have resulted in what many environmental groups see as unnatural due to inadequate mitigative measures and procedures. Prescription fires are now designed to mitigate these effects through "cool burns" meant to restore natural conditions. The overall concern is to have the forest "look" like a low intensity burn has moved through the forest even though the fuel load has the potential for a high intensity fire.

Research Procedures and Methodology

The procedures applied for this research (Dawson and Greco 1987) were determined based on the specific needs of management and recommendations from the Panel Report (Christensen 1987). They consist of (1) delineation of the viewshed boundaries of the SMAs, (2) inventory and analysis on the visual resources within the SMAs, (3) ecologically acceptable visual resource management goals and objectives, and (4) management treatments which fulfill the visual quality goals and objectives.

The research consisted of an inventory of visual resource elements, formulation of goals and objectives, and development of a set of guidelines for treatments of fire effects on the character of the landscape and on the character of individual giant sequoia features. The methodology developed for assessing the visual resources at Sequoia National Park can be applied to all roadways and trails within the park. The process model (*fig. 1*) graphically depicts the recommended methodology for SMA visual resource planning.

SMA Boundary Delineation

The study areas within the SMAs are defined in terms of their respective viewshed boundaries. A viewshed, or visual corridor, is a routed (by road or trail), physically bounded area of landscape that is visible to an observer (Litton 1979). A viewshed delineates the dimensions of the "seen" environment in terms of visual penetration. The viewshed boundary is formed from the dynamic composition of viewing points on a continuum (i.e., a road or trail). Viewing points are representative of a number of observer positions accounting for several viewing orientations (Litton 1973, 1968). It should be noted that because natural features often delineate visual units (ridges, streams, etc.), ecological units (i.e., watersheds) and visual units (i.e., viewsheds) are closely related.

Visual Resources Inventory and Analysis

An inventory of visual resources is a descriptive field survey that identifies the seen areas, and physically locates

visual and perceptual elements within the selected SMA study areas. It consists of several parts including viewshed delineation, areas of viewshed overlap, visual unit delineation, identification of special features and visual element subunits, determination of giant sequoia visibility through a visual prominence rating, and the location of impacted views due to fire suppression. An inventory was surveyed and compiled for each study area SMA.

The goal of the feature analysis is to provide park managers with a tool to assess the relative difficulty of achieving the visual quality objectives. The Management Scale provides an indexed classification for each visual unit to indicate pre-burn planning intensity and (burn) labor requirements that will be necessary for any given burn unit. For example, in an area with many visual features (i.e., giant sequoias, logs, etc.) the Management Scale value could be rated as class "1" and an area with few visual features could rate as a class "4" value. Thus, if a burn unit contains several class "1" values, then more labor will be required to mitigate excessive fire effects. This would be the case whether or not a biological or aesthetic basis was used simply because of the resource base. The formulation of the Visual Unit Management Scale is composed of five steps: a tabulation of features per visual unit; a feature aggregation index calculation; determination of visual unit acreage; a feature density value calculation; and an indexed classification of those values into the Visual Unit Management Scale values.

SMA Visual Management Goals and Visual Quality Objectives

Fire management planning in SMAs requires the development of clear goals and specific objectives as a critical step in the prescribed fire planning process (Bancroft 1983; Fischer 1985). Clear exposition of goals and objectives is necessary to evaluate the effectiveness of management actions. Management goals should be broad in scope and attainable through specific objectives that address issues within each goal. The three central issues for visual quality goals and objectives are (1) fire effects on the character of the landscape, (2) fire effects on individual giant sequoias, and (3) enhancement of currently affected visual resources.

Fire Effects on Landscape Character

The giant sequoia/mixed-conifer forests have evolved in context of frequent fire return intervals and low fire intensities although less frequent, more extensive and intense events have also played an important role in this ecosystem (Kilgore 1987; Van Wagendonk 1985). Kilgore and Taylor (1979) found through tree ring analysis that historical fires near the Giant Forest area were frequently small in size and generally confined to a single slope or drainage. They also report that fires ranged in size between 0.001 ha to 16 ha. In the same study area, Harvey and others (1980) confirm the small nature of these burns, suggesting they were about 10 ha.

In the Redwood Mountain area, the Kilgore and Taylor study (1979) also found fire return intervals on west-facing

METHODOLOGY: PROCESS MODEL

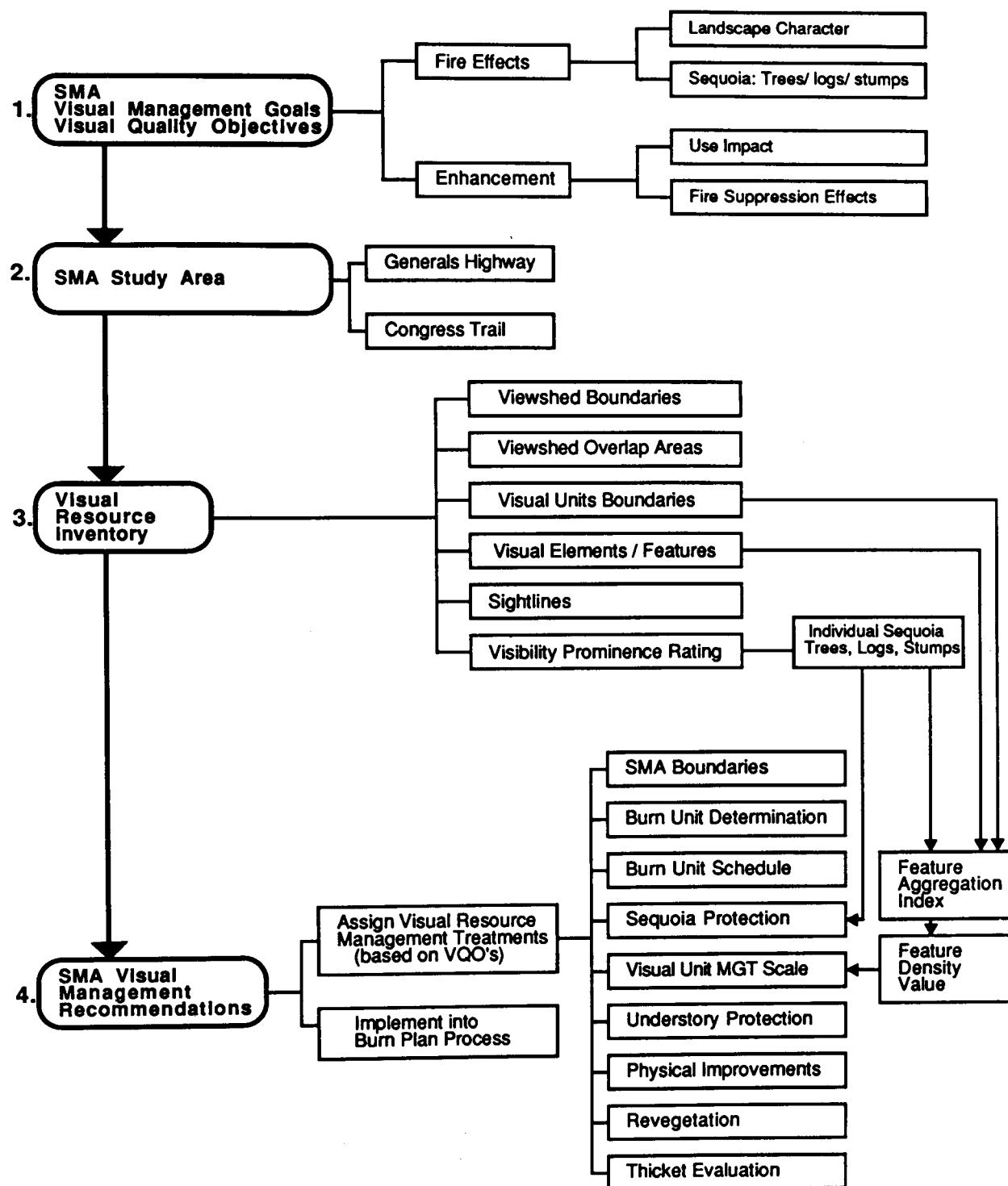


Figure 1-Visual resource research methodology and planning approach.

slopes to be about every nine years, and on east-facing slopes to be about every 16 years. They also report mean fire-free intervals of five years on dry ridges of ponderosa pine and 15 to 18 years in moist sites of white fir. The average maximum fire-free interval was found to be 14 to 28 years. Nonetheless, their data also reveals that some clusters of giant sequoias have escaped fire for up to 39 years. Some areas have possibly escaped fire for a hundred or more years.

Restorative SMA prescription fires should be planned within an appropriate temporal and spatial framework. The juxtaposition of prescribed burns can greatly enhance or detract from the visual and ecological diversity of the forest. The goal should not be to create burns that result in large scale areas of an early successional stage. Rather, management burns should concentrate on maintaining, or creating, successional diversity throughout the forest (Harvey 1980). Fire should be introduced on a gradual spatial and temporal basis to restore the forest to a more natural state. Although reducing fuel accumulations is important, it is not necessary that this be the immediate objective of an SMA burn. Small-scale burns should be designed that maintain ecological and visual diversity over appropriate time scales. Planning should incorporate available site-specific fire history research.

To preserve successional and visual diversity, management plans should include small-scale burns, random juxtaposition of burns (variety of burn unit contrasts), selected retention of understory vegetation, and limiting the number of burn units treated each year. Planned variation in future burn unit boundaries will also help maintain an ecologically and visually diverse park environment. To increase visual diversity and maintain a sense of ecological continuity along travel corridors, burn unit boundaries should cross roads and trails in some areas and remain adjacent to them in others. If roads and trails are always used as boundaries, one side will always appear different than the other creating an unnatural experience. Human infrastructure should be avoided or limited as burn unit determinants. Overuse of them could lead to a confused perception of the forest to some visitors and contribute to a less naturalistic aesthetic. Extended long-range plans, or areas in need of a second prescribed burn, should include planned variation from the boundaries of the first prescribed burn, or possibly the relocation of trails during this planning process. It is not recommended that the same boundaries be used for future burns. The return of fire should also be variable, both spatially and temporally. Variation is another very important aspect of visual and ecological diversity, as pointed out in the Christensen Report (1987).

Treatments of designated SMA burn units should be "cooler" prescriptions as noted in the Grant Tree SMA plan (NPS 1980a). Taylor and Daniel (1985) confirm that fire intensity correlates with scenic quality and recreational acceptability in ponderosa pine forests. They found that in comparison to unburned areas, low intensity fires produced improved scenic quality ratings after 3 to 5 years, but that high intensity fires "seriously declined" in scenic quality

ratings after the same time period. This is especially true of areas that are under intense recreational pressure where regeneration is hindered by trampling impacts.

Efforts to provide a high value interpretive program are essential to educate the public about fire ecology and the aesthetic implications of fire ecology in the Giant Forest SMAs. The program is important because visitors are barraged with fire danger signs as they approach the park. McCool and Stankey (1986) found that visitors who were confused and uncertain about the effects of prescribed fire were afraid that it could be "detrimental" and negatively impact the park, but that visitor center exhibits and guided tours help engender an understanding and appreciation of the dynamic processes of forest succession and fire ecology. Roadside and trailside interpretive displays in appropriate locations, with descriptive graphics facilitate this objective. The Hazelwood Nature Trail is an excellent example. Hammit (1979) indicated that the value of interpretive displays located in visually preferred areas can be more rewarding and more likely remembered. Proper placement of displays in the environment appears to aid in the memory process of park visitors.

Fire Effects on Individual Giant Sequoia Trees, Logs, and Stumps

Visual features in the Giant Forest are highlighted by the grandeur and presence of a high density of giant sequoias. As a result of this density and the park's design, visitor appreciation of the giant sequoias has rendered many of them as unique natural/cultural objects in the landscape. Hammit (1979) reports that the most remembered scenes by visitors are characterized by visually distinct features. It appears there is a strong correlation between familiarity and preference of scenery. Familiarity is highest in both most preferred and least preferred scenes, indicating that visitors are affected by both positive and negative features observed in landscape experiences. Preferred areas within the park are trails, such as the Congress Trail, that were designed with the objective to guide visitors to experience the high densities of giant sequoia groves.

Maintaining high scenic and recreational values in the Giant Forest requires sensitive visual resource planning of fire effects and a strong interpretive program to effectively communicate fire ecology to the public. Protecting all sequoias from intensive fire effects however, may not be possible. Since the giant sequoias are a primary visual resource (and biological resource) in the Giant Forest, the most prominent trees should receive the greatest mitigative measures (if resources are limited) to retain a natural character following restoration burns. It is recommended as a visual quality management goal that distinct foreground features receive judicious burning, especially around the bases of the giant sequoias in the SMAs of Sequoia National Park. The foreground trees are most impacted by intense human use and, therefore, most impacted and most visually vulnerable.

For visitors to gain a sense of appreciation for a wide range of fire effects, some of the less prominent trees could provide an opportunity for such diversity. It is not intended that foreground trees should be protected at the expense of background giant sequoias. Rather, since foreground sequoias are proximate to high human use pressures and park infrastructure—which result in decreased duff cover soil compaction, increased erosion and lack of understory regeneration—these trees should receive more sensitive treatment. Background trees could receive wilderness standards for giant sequoia protection.

To gain better insight and understanding of visitor sensitivity to singeing and charring on highly visible giant sequoias, a special study would have to be conducted. A study has been completed of visitor perceptions of recent prescribed fire management in Sequoia National Park and generally, visitors were not adverse toward fire scars (Quinn 1989). No research however, was conducted on reaction to singeing versus charring in recent burn units within the park.

The last issue regarding protection of individual giant sequoias is the maintenance of ecological and visual/cultural values associated with horizontal features in the forest landscape experience. The preservation of a select number of highly visible sequoia logs (in addition to named logs) along trails and roadways has been strongly recommended by some groups (Fontaine 1985). The interpretive value of these logs stems from the direct "involvement" the public has with these elements. The tactile experience of touching and passing through these logs can engender a strong appreciation for the grandeur of the giant sequoias. They also demonstrate the dynamic nature of succession in the giant sequoia/mixed-conifer ecosystem. Hammit (1979) suggests that prolonged contact with such features increases familiarity. It was recommended that a balanced number of strategically located logs be protected from intense prescribed burns and not burned unnaturally.

Currently Affected Visual Resources

Scenic resources that are currently impacted are the result of intensive recreational use, and the structural changes of vegetation in the giant sequoia/mixed-conifer forest. The first is due to the effects of visitor overuse and the lack of facilities to accommodate the use volume. The second impact results from fire suppression which promote the growth of shade tolerant conifer thickets (non-fire climax species) that unnaturally limit the visibility of numerous giant sequoias within the viewshed. Management goals to alleviate both of these impacts would enhance the overall experience of the park.

Many high visitation areas such as the Congress Trail, General Sherman Tree, and Hazelwood Nature Trail suffer from severe overuse. Strategic signs in these areas is essential to better guide foot traffic (trampling) in these areas which has caused the disintegration of duff and subsequent erosion of surface soil inadvertently creating biological and visual resource problems. Problems include erosion around sequoias

exposing fibrous roots, erosion and decay of asphalted edges in parking areas and on trails, and a lack of understory vegetative cover due to soil compaction. Means to reduce these effects include redirecting foot traffic in and around facilities and reduced trampling around the trees.

The second issue concerning enhancement of affected visual resources centers on the extensive growth of shade tolerant conifer thickets (non-fire climax species) resulting from fire suppression and the disturbances due to road and trail construction (Bonnicksen 1985; NPS 1980b). In the absence of regular fire disturbance cycles these thickets have grown unchecked by natural process, thus hindering the ability of the giant sequoia to reproduce successfully and also blocking both historic views and potentially valuable views of the giant sequoias in the Giant Forest SMAs. In addition to these problems, the thickets also represent future fuel load and fuel ladder problems. The visual resource goal should be to conserve the scenery while enhancing natural visitor experience within the SMAs through active management of the thickets. The means to achieve this goal include increasing the visibility of the affected giant sequoias through limited and strategic removal of these "overrepresented aggregation types" to maintain a more natural aesthetic in the Giant Forest (Bonnicksen 1985; Cotton and McBride 1987).

Visual Resource Treatments

The recommended treatments are composed of a Landscape Management Plan and a set of guidelines for visual resource management in the SMAs. Visual resource treatments are management actions designed to fulfill management goals and visual quality objectives. A photographic monitoring program is also recommended.

Landscape Management Plan

The SMA Landscape Management Plan identifies proposed burn units, planning units, past prescribed burns, burn exclusion areas and thicket problem areas. The burn units have been designed in accordance with the visual quality objectives to maintain a diverse visual character within the SMA study areas. Sections requiring additional research studies are classified as "planning units" and "SMA planning units" on the plan. Small areas of cultural value that are recommended to be excluded from prescribed fire are also indicated on the plan. Additionally, thickets that block views of giant sequoias, and thickets that present future visual resource problems are identified for treatment. Finally, measures to protect visually prominent giant sequoias are based upon the visual prominence ratings as shown on the Visual Resource Inventory maps.

Protection of visual elements is also meant to preserve pockets of mature understory vegetation in addition to giant sequoia protection. These pockets are ecologically important because they function as vegetative buffers which are needed to avoid further damage from intensive human use interfering with regeneration and colonization sources. These, too, are

identified on the Visual Resource Inventory Maps. The analysis of visual features within the visual units provides a guide for resource managers to evaluate labor requirements when planning burn units. A feature "density" value was generated for each visual unit and broken down into management intensity classes.

Burn Unit Design and Schedule

Burn units were designed based on the Fire Effects Guidelines for SMA Landscape Character. Natural boundaries for the SMA burn units are preferred to artificial boundaries. It is recognized that the use of roads and hiking trails for fire breaks is essential in many cases due to economic constraints. Alternatives to their use however, should be explored, such as streams, drainages, ridges, old fire lines, meadows, rock outcrops, and new fire lines.

The burn units in a maintenance fire regime should be varied from previous prescribed burns. It is not recommended that the same burn unit boundaries be used more than once if they are unnatural boundaries (trails or roads). Using the same boundaries runs an ecological and visual risk of creating an unnatural mosaic of forest succession. The maintenance burn regime units should concentrate on natural fire breaks that travel across trails instead of being bound by them.

Timing of the burn units is a very important aspect of planning. The burn units have been designed to restore

the Congress Trail and the SMA section of the Generals Highway to more natural conditions. Following the restoration burn regime, a long-term maintenance fire regime should be formulated for the Giant Forest. It is recommended that this regime be based on area-specific fire history research. A computer geographic information system (GIS) would greatly enhance the analysis and planning of the burn units in the Giant Forest because it is a very useful tool for evaluating large spatial data sets and many variables.

Guidelines for Thicket Problem Areas

The visual quality objectives regarding enhancement are designed to increase the visibility of giant sequoias affected by extensive thicket growth throughout SMA viewsheds. These thickets are blocking numerous potentially valuable views of giant sequoias (*fig. 2*). Management for a natural aesthetic and increased visual penetration into the forest within the SMAs warrants judicious mechanical thinning of some of these thickets (Bonnicksen and Stone 1982; Christensen 1987; Cotton and McBride 1987).

The thickets were mapped on the SMA Landscape Management Plan in two ways. Existing "blocked" views were mapped, and visually "encroaching" thickets are also shown. The encroaching thickets did not present a visual problem at the time the field work was conducted, but will



Figure 2-Thickets of mixed conifers encroaching on the views of giant sequoias due to the disturbance of road construction.

cause visual penetration problems in the near future. They should be monitored photographically and evaluated for mechanical thinning. It was recommended that this be incorporated into the park's Vegetation Management Plan for the development zone (NPS 1987b).

Guidelines for Giant Sequoia Fire Effects Mitigation

As discussed in the visual quality objectives, it is the visually prominent trees which are impacted most by human use pressures. Park infrastructure, such as trails, roads, signs, restrooms, etc., are proximate to the visually prominent trees. The most valuable scenic resources are also the most visually prominent trees. Mitigative measures to protect these trees are critical in terms of ecological, scenic, and park infrastructure resources. The objective is not to leave these trees unburned, but to mitigate fire effects. Trees impacted by intensive human use are under stress and unsuppressed fire risks unnatural mortality. The four categories of giant sequoia protection (mitigation measures) are illustrated in figure 3 and include: (1) scorch exclusion, (2) minimal scorch, (3) limited scorch, and (4) unsuppressed scorch (within standard management tree protection guidelines). These relate directly to visual proximity as well as distance from human impact (Dawson and Greco 1987).

To understand properly the descriptions of the four categories of giant sequoia protection, definitions of scorching, singeing and charring are needed. In this study, "scorching" is the singeing or charring of sequoia bark. "Singeing" is bark ignition to a depth under one-half inch ($<1/2$ "). "Charring" is defined as bark ignition to a depth over one-half inch ($>1/2$ "). The question of singeing is not an intense aesthetic issue because park visitors seem to accept some fire damage to sequoias (Quinn 1989). However, reaction to varying levels of charring is undetermined and can impair the scenic quality of giant sequoias for longer time periods if the trees are under stress, especially when there is increased mortality. Therefore, it was recommended that scorch and char guidelines be established in addition to current tree preparation standards (pre-fire) and firing techniques. It should be remembered that the guidelines apply only during the restoration fire phase.

Guidelines for Understory Protection

Planned retention of pockets of understory vegetation is recommended in the SMA burn units. They offer opportunities to maintain visual and ecological diversity while increasing the probability of regeneration by providing colonization sources. Often, these pockets grow among rock outcrops and may have escaped fire for long periods under more natural wildfire conditions. Historically, natural burns have undoubtedly missed many areas creating a mosaic of vegetation characteristic of the sequoia/mixed-conifer ecosystem. The most obvious pockets for retention would be growing among rocks that could be supplemented with fire lines to lengthen their presence.

For aesthetics, these groups of plants provide a visual focus, diversity of elements, and demonstrate the scale

between visitors and the large-scale giant sequoias and older conifers. Some good examples in the Giant Forest are native dogwoods (*Cornus nuttallii*), Sierra chinquapin (*Castanopsis sempervirens*), and greenleaf manzanita (*Arctostaphylos patula*). Although some are adapted to fire and regenerate after a fire, their rate of growth is slow. Their visual, ecological, and interpretive qualities could be diminished for many years.

Discussion

There has been concern on the part of National Park Service scientists about some of the research recommendations on visual resources (Dawson and Greco 1987). An interdisciplinary group of staff from Sequoia National Park representing science, administrative management, visitor interpretation, fire management, and resource management met and forwarded comments. The following discussion presents these views as well as further discussion on the visual resource research.

NPS and Understory Issues

The NPS group does not favor "the deliberate retention of mature groups of understory plants, since prescribed fire tends to leave mosaics of burned and unburned areas, and the recovery of the understory plants in post-fire succession is an important part of the forest story" (NPS 1988).

At several prescribed burns in the Giant Forest, the visual resource research team observed that fire was applied homogeneously within the burn units. Fire management staff frequently burn areas completely and uniformly, and if fire bypassed any fuel loads, the fire technicians returned moments later to fire that area. This does not mimic natural fire patterns and as a result, pockets of understory plants rarely survive. The practice of multiple-spot firing after the fire has moved through should be modified to rely on this technique only in situations where absolutely necessary. Kilgore (1985) supported this concept by pointing out that increased uniformity and lessened mosaic pattern is also ecologically unnatural. Again, visual ecology and biological ecology coincide.

Litton (1988) has written to staff at Sequoia National Park that "In addition to modifying fuel concentrations, both down material and standing live trees, related to dominant specimens, I further urge protective measure for certain visually significant understory-ground floor components. Several obvious examples of these subordinate features are snags, fallen big trees and mature, tree-form dogwoods; these and others contribute significantly to experiencing a rich landscape, are signs of time and succession, and represent considerably more than fuel needing to be burned."

Litton further added,

"Brewer, King, and Muir confirm and give emphasis to other contemporary accounts that the Sierra Nevada forest were [sic] impressive for their [sic] openness and for the large scale of mature trees. At the same time, these three early observers note the diversity of what they saw in the

various forest and woodland species, their associations, regeneration and some of the ground plane and understory characteristics. Brewer notes species or type distribution in space and elevation, the combinations of the mixed conifers --some with Big Trees, the array of ages and sizes in Big Trees, [and] the significance of fallen Big Trees in appreciating their size and age. King emphasizes the impact of contrasts found in the association of Big Trees and Sugar Pine and White Fir as well as the experience of the spatial quality found in the open forest. Muir comments on openness, on spatial distribution, on the smooth floor, but also points to the contrast of underbrush with Big Tree bark and speaks in considerable detail about Big Tree regeneration. Diversity, then, appears to be an historic clue about the historic forest in addition to the frequently stated perception of openness."

NPS and Visibility Issues

The NPS group "was unanimously opposed to allowing changes in appearance due to fire only in the medium and low visibility trees, while retaining foreground trees in their present unburned state... in general, all trees regardless of [visibility] rating will be prepared and burned according to current standards" (NPS 1988).

In the visual resource recommendations, scorch exclusion does not mean "unburned." More importantly, it will be very difficult to treat focal point trees, such as the General Sherman Tree, with intense prescribed fire. These trees are surrounded by trails, fences, facilities, and/or roads and are also subject to intensive visitor use and abuse. Most foreground trees in special management areas are stressed by pavement, soil compaction and altered topography. As one moves farther from view corridors, this type of impact (direct human disturbance) is lessened. It is evident that there is an ecological relationship between aesthetics and human use of the built environment. Treating giant sequoias in the foreground more sensitively than those further away actually recognizes the reality of conditions.

NPS and Downed Log Issues

The NPS Group agreed that "logs identified by interpretation as having cultural or interpretive value will be protected from fire. However, no effort should be made to preserve logs as horizontal elements, since these logs are important sources for seedbeds, which are an important part of the forest story. In addition, the SMA burn units are small, and it is not likely the loss of logs will produce an impact on the visual resources of the area as a whole" (NPS 1988).

Many western wildfires document that horizontal elements (logs) are increased by fire, not decreased, regardless of fire intensity (Ekey 1989; Guth 1989; Simpson 1989). Although it is difficult to compare many wildfire situations, logs are universally important ecologically and visually for the maintenance of habitat diversity. It is important to avoid the homogeneous burn coverage typical of hot fires in unnatural fuel accumulations. While totally burnt logs can

play a role in sequoia regeneration, firing techniques which attempt to burn all logs does not recognize that some logs also play an important role in the nutrient cycling of the forest by acting as nutrient reservoirs, biological reservoirs, and reducing soil erosion following a fire. If the fire burns a log as it moves through, this seems acceptable and natural. The problem is when fire crews return to spot-burn a log that the fire has by-passed.

NPS and Thinning Issues

The NPS group also agreed that "existing vistas of the Sherman, Grant, and McKinley trees should be preserved. The group was opposed to pre-burn thinning of trees which obstruct sequoias as well as to the suggestion that trees killed by the fire should be cut out" (NPS 1988).

In discussing visual resources, the many thickets exist because of park development (i.e., canopy opening) and are diminishing the scenic value of the park from roads and trails (*fig. 3*). Many of these thickets are less than fifty years old and exist as a result of managed fire exclusion and site disturbance, such as road construction. These newer thickets do block historic views, but just as importantly, also impact biological processes. Kilgore (1987) states that "removing fuel from the intermediate layer between surface and crown fuels greatly reduces the potential for high intensity surface fires that could lead to crown fires." Under a more natural fire cycle, crown fires are a relatively rare event in the giant sequoia/mixed-conifer ecosystem and would be an unnatural and unfortunate consequence of fuel load due to past fire suppression. The Christensen Report (1987) indicates approval of judicious pre-burn cutting of understory trees ... where ignition of such trees might have a negative effect on stand appearance and/or when their removal would enhance the visual effect of adjacent specimen trees."

Conclusion

Past human interference with the ecosystem of the giant sequoia/mixed-conifer forests has impacted the visual and ecological resources in Sequoia National Park. These impacts have been augmented by concentrated visitor pressure in the areas of the park with roads, trails, and built facilities. "Special Management Areas" SMA's have been established to address these complex management problems of balancing cultural and natural ecosystem interests.

The management goals at Sequoia National Park are to restore the fire climax ecosystems of the giant sequoia/mixed-conifer forests to more natural conditions through the reintroduction of fire after many years of fire suppression (Parsons and Nichols 1985). Objectives of past burns to reduce fuel loads have overlooked the need for mitigation in the areas that are under heavy impact from human use. The sensitive treatment of scenic resources in these SMAs can augment natural diversity if the structure of "naturalness" is given priority over uniformity of fuel load reduction. Management actions should seek to: (1) mimic natural fire

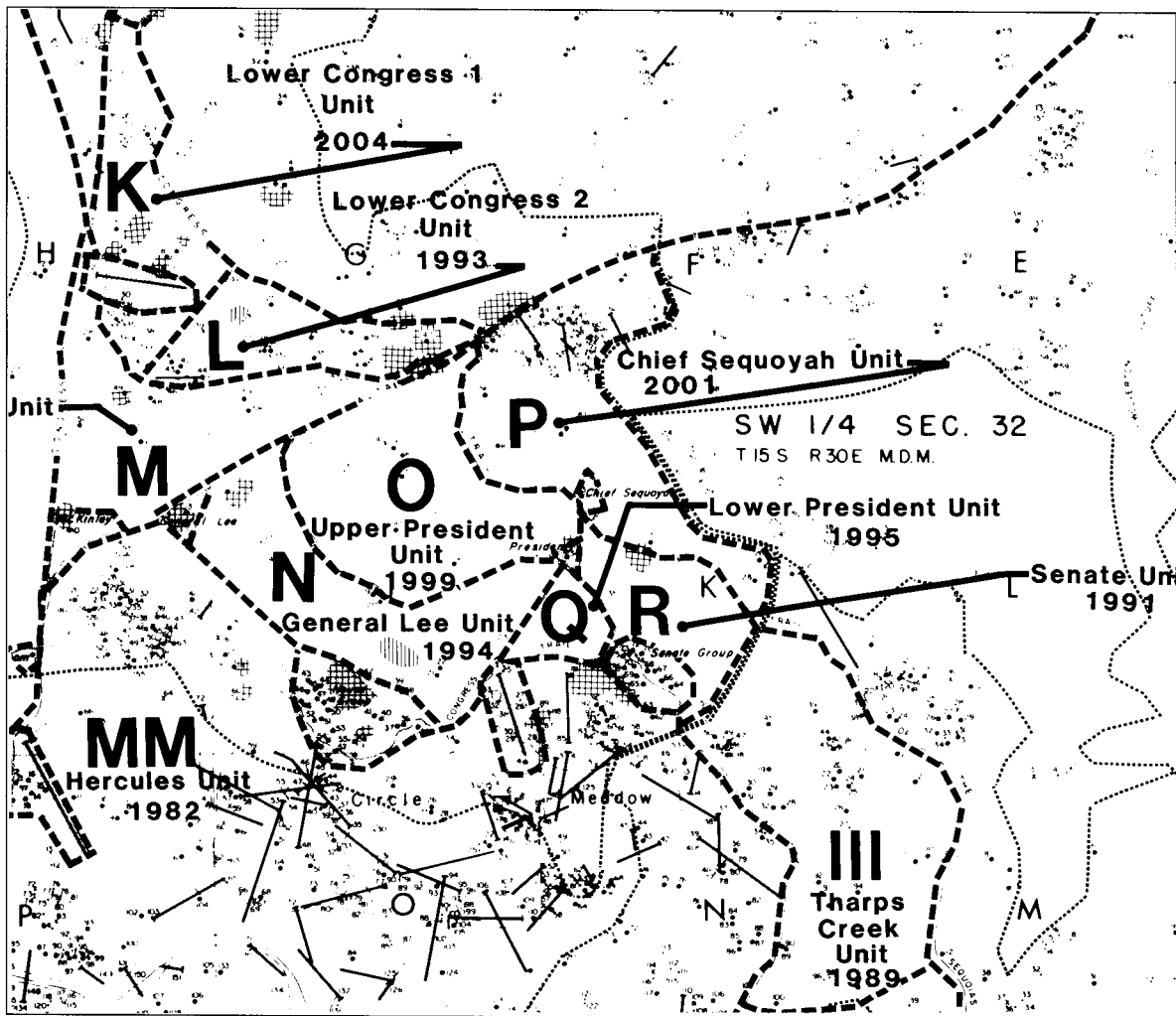


Figure 3-SMA mitigation measures for giant sequoias.

patterns whenever possible; (2) avoid artificial infrastructure as burn unit determinants; and (3) conserve and enhance scenic resources in areas threatened by intensive human use.

The detailed visual resource database and mitigation guidelines developed for the Sequoia Prescribed Fire Management Program were designed to provide park resource managers with tools to achieve more natural fire effects for the landscape and giant sequoia visual resources. There were forty-four separate treatments recommended with roughly half of the recommendations known to be implemented (Dawson and Greco 1987). It is pleasing and appreciated that support was readily forthcoming from the National Park Service for over half of the treatments. This paper has attempted to explore the complexities of the remainder. Creating favorable ecological conditions for the perpetuation of the giant sequoia is supported in this paper and prescribed fire management is a necessary approach. The goal of visual resource research has been to present ecologically acceptable solutions to problems of culture in the context of the natural environment and to study and manage the role of fire in supporting this continued improvement.

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